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USERS' EVALUATION OF THE NAVY COMPUTER-ASSISTED MEDICAL DIAGNOSIS (NCAMD) SYSTEM

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Errata Sheet

Page i, paragraph 1, line 15: change word "health care" to "patient."

Page i, paragraph 3, change "Group Medical Officers" to "General Medical Officers."

Page 7, paragraph 2, line 16: The sentence "The Respondents thought the diagnosis of nonspecific abdominal pain was confusing and should therefore be deleted from the system" should have appeared on page 8, paragraph 5, line, 2.

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Summary

Problem: U.S. Navy Independent Duty Corpsmen (IDCs) aboard small ships and submarines are responsible for the diagnosis and treatment of patients while at sea. Although IDCs safely manage the majority of the patients, some life-threatening illnesses require IDCs to recommend that patients be evacuated to a shore-based facility for treatment. At-sea evacuations of patients are dangerous to the patient, expensive, and may compromise the mission of the ship or submarine. An IDC's decision regarding the need to evacuate a patient may be complicated by an inability to conduct certain tests because of a lack of shipboard laboratory facilities. Furthermore, mission requirements frequently preclude communicating with shore-based physicians for consultation. Usually, a single IDC is assigned to each small ship or submarine and is tasked with all clinical and related health-care duties for embarked personnel. A system is needed that would aid IDCs in the evaluation, treatment, and management of health care aboard ships and submarines.

Objective: The objective of this study was to gauge the practical implications of IDCs employing a user-friendly computer-assisted medical diagnostic (CAMD) system to aid in the diagnosis of disease and to perform tasks related to the treatment, evaluation, and management of patients.

Approach: The Navy Computer-Assisted Medical Diagnosis (NCAMD) system was installed aboard U.S. Navy ships and submarines with GMOs or IDCs attached. Both the Group Medical Officers (GMOs) and IDCs were trained in the functioning and use of the NCAMD system, and given the software to use and evaluate during deployment. When they returned from deployment, the GMOs and IDCs were surveyed and interviewed to determine their opinions of the NCAMD system.

Results: The results show that NCAMD software was user-friendly, easy to learn, valuable for training, and could significantly contribute to health-care delivery. However, NCAMD was installed on the ships' available computer hardware, which was reported as slow, and inhibited the continuous use of NCAMD. NCAMD users stated that the addition of a variety of modules, structured data sheets, treatment and reference materials, and peripheral devices would increase value and usage of the system.

Conclusions: The NCAMD software is a cost-efficient and user-friendly package that is easy to learn and is of particular value for training in the diagnosis of chest and abdominal pain. However, the delivery of health care at sea would significantly improve if the computer hardware were upgraded to current industry standards. Also, adding various computer peripheral devices, structured forms, and reference materials to the at-sea clinician's resources could enhance shipboard health care.

Introduction

Numerous computer-assisted medical diagnosis (CAMD) software programs have been created to aid clinicians in the diagnosis of disease (Waxman & Worley, 1990). These programs have been tested extensively and their diagnostic accuracy has been found to be, for certain diseases, better than that of the average clinician (de Dombal, 1989; McAdam et al., 1990; Patterson-Brown & Vipond, 1990). CAMD programs have also proven to be of value in the area of clinical education because they improve data collection procedures by imposing a structure upon the gathering of signs and symptoms of illness (Lawrence, Clifford, & Taylor, 1987). Despite the well-documented advantages of CAMD programs, there has been little use of the programs (de Dombal, Dallos, & McAdam, 1991). Therefore, it appears that CAMD programs are not used for reasons other than their diagnostic accuracy or their value to clinical education.

CAMD developers in the early 1960s believed that their systems would eventually replace clinicians. Their omnibus systems were overly ambitious, especially when the unwieldy hardware and the available software, limited by the computers' memory, are taken into consideration (Dallos & Cunningham, 1990). Through the 1980s, hardware capabilities lagged behind the development of software, which made the use of CAMD systems time-consuming and impractical. However, with the recent development of faster central processing units (CPUs), the practical and efficient use of CAMD software is now possible, which may lead to greater acceptance of CAMD systems. Instead of CAMD systems replacing clinicians, however, it has been found that CAMD systems that consider finite clinical problems can augment the diagnostic skills of clinicians, teach and guide inexperienced clinicians, and aid in promoting a standardized method for evaluating patients (de Dombal et al., 1991; Wellwood, Johannessen, & Spiegelhalter, 1992). Overall, studies have shown that CAMD systems can complement the clinicians' previously acquired skills (Dallos & Cunningham, 1990; de Dombal, 1990a; Waxman & Worley, 1990).

For more than a decade, the Naval Submarine Research Laboratory (NSMRL) developed CAMD modules for use by Navy Independent Duty Corpsmen (IDCs) and Group Medical Officers (GMOs). GMOs, physicians stationed aboard large Navy ships, are responsible for the health care of all attached personnel and the supervision of all IDCs under their level of command. Quite frequently, lone IDCs assigned to Navy vessels are responsible for the health care of more than 250 personnel (Nice, 1984). IDCs are specially trained, nonphysician health-care providers who are responsible for the diagnosis and treatment of patients who incur trauma and illness while at sea aboard submarines and small ships. Although the IDCs safely manage the majority of patients, some life-threatening illnesses require the IDCs to recommend that the patients be evacuated to a large ship or shore-based activity. The evacuation of patients while at sea is dangerous to the patient, expensive, and may compromise the mission of the submarine or ship. The IDC's decision of whether to evacuate may be complicated by a lack of laboratory facilities and diagnostic equipment and by an inability to communicate with physicians, imposed by mission requirements. Therefore, CAMD modules were developed to assist IDCs with the diagnosis and treatment of patients who present with abdominal pain, chest pain, trauma, dental, ophthalmologic, or psychiatric complaints (Caras, Southerland, & Fisherkeller, 1989). These diagnostic categories have been shown to be the most common areas wherein

IDCs and GMOs have required assistance (Nice, 1984). The performance of NSMRL CAMD modules for chest pain and for abdominal pain have been tested at sea and found to be of value when the patient's diagnosis is in doubt (Luria, Southerland, & Stetson, 1990; Perrotta & Stetson, 1992).

IDCs are also tasked with a variety of professional and military duties. Their professional duties include cleanliness and environmental hazard inspections, physical examinations, health education, and routine and emergency sick call. Additionally, they may be assigned collateral duties and must perform routine military duties. Their professional duties require the completion of periodic hard copy reports that are sent to higher echelons of command. Consequently, much of their time is occupied with report writing and handling of forms.

Recently, the Naval Health Research Center (NHRC) integrated the patient functions of the NSMRL CAMD module shells with those of the Shipboard Non-Tactical ADP Program (SNAP) Automated Medical System (SAMS) and created one diagnostic package. Because this system has been designed to be used in Navy shipboard environments, it is referred to as the Navy Computer Assisted Medical Diagnosis (NCAMD) system. SAMS has been installed at more than 500 Navy facilities. NHRC programmed the enhanced patient encounter module, incorporated it into SAMS, and added the following capabilities: (1) computer-assisted diagnostic support, (2) an ICD-9-CM diagnosis look-up table, (3) an SF600 facsimile, (4) a medical evacuation data entry form, (5) an expanded patient encounter form, and (6) monthly morbidity reporting functions. NHRC's overall goal was to enhance health-care delivery by reducing the IDCs' routine work load and by providing adjunctive clinical assistance in the form of NCAMD. To this end, NHRC created a flexible, computerized, and user-friendly management information system that would integrate a structured means of sign-symptom gathering, diagnostic assistance, and the production of standard reports and forms. This system will allow the IDC to more efficiently and accurately complete many tasks that had previously been done manually, thereby allowing the IDC to devote more time to direct health-care delivery (Ly, Merrill, & Pearsall, 1993).

De Dombal (1990a) outlined the following difficulties associated with the implementation of CAMD programs: (1) clinicians are unwilling to believe that CAMD programs can enhance their performance, although the complexity of clinical medicine has increased dramatically and ample evidence supports the claim that diagnostic skills can be improved with CAMD programs; (2) CAMD programs need to be developed that prescribe that structured methods be used to gather patient data and case histories; (3) user-friendly interfaces need to be developed (de Dombal stated that the development of user-friendly interfaces in the field of clinical computing requires "urgent action"); (4) the debate concerning which system is best, probabilistic or deterministic, needs to stop, since both systems appear to produce similar results; (5) the problem of which information to give the clinician: a diagnosis, a list of possible diseases with their probabilities, or a suggestion of what the diagnosis may be with options that may be investigated; (6) the problem of convincing clinicians that their performance improves because they have a disciplined method for data collection, they have learned common terminology, the computer is a tutor and provides feedback, and the CAMD system incorporates practices that have been shown to be effective by

experienced clinicians; and (7) the lack of a computer-literate work force, educated in the prudent use of information technology.

This study was done to gauge the practical implications of employing a user-friendly CAMD system to aid in the diagnosis of disease and to perform tasks related to the treatment of patients. For many reasons the intended users of CAMD systems are not using CAMD programs. Although de Dombal (1990a) has suggested various problems associated with the implementation of CAMD systems, few studies have been done that have solicited potential users' opinions.

Method

There appears to be ample evidence for the implementation of CAMD systems aboard ships and submarines. For example, they have been shown to have numerous benefits for clinicians and patients (Dallos & Cunningham, 1990; de Dombal, 1990a; Waxman & Worley, 1990), their placement and use aboard U.S. Navy ships and submarines suggest that health-care delivery is enhanced (Nice, 1984), and they have been found to be of value at sea when the patient's diagnosis is in doubt (Luria et al., 1990; Perrotta & Stetson, 1992). To evaluate the need for the implementation of NCAMD, the system was installed aboard 20 U.S. Navy vessels (10 ships and 10 submarines) with IDCs or GMOs attached. Some of the vessels have more than one IDC embarked. All of the NCAMD systems were installed by NHRC personnel or by extensively trained IDCs or GMOs.

Apparatus

Most of the ships and submarines on which NCAMD has been installed have computers with 286 CPUs. These systems are comparatively slow; therefore, many ships and submarines are in the process of upgrading their systems to 486 CPUs.

The user interface for NCAMD has been implemented as a window-oriented environment. The use of NCAMD has been detailed in Ly et al. (1993). The window structure is character-based, which allows it to be used on a variety of systems and its code to be adapted to other system environments.

The development of a user-friendly interface for NCAMD was based on the philosophy of Roth, Di Stefano, and Chang (1989). They found that: (1) the simpler a system is the more it will be used, (2) the quicker a system can be learned the more that will be learned about its application, and (3) the system will be simpler and easier to learn if its use is intuitive. Therefore, the user interface of NCAMD has the following characteristics:

(1) To facilitate the processing of patients and to minimize the impact of using the system on the IDC's time, the entry of data and responses were optimized for speed.

(2) To allow for system use by a wide range of computer-experienced users, the system was designed to function by memorizing a few special keys or by use of a mouse.

(3) The system has been simplified by making the key and mouse operations consistent throughout the program. Key and mouse functions are not different at different levels of the system.

(4) The system contains context-sensitive flexibility. Numerous correct and incorrect user responses are identified by the system.

(5) The orientation of the user throughout the system is aided by means of context-sensitive help. This allows the user to receive instructions when in doubt about how to proceed.

(6) Finally, to enable the user to feel secure when using the system, it was designed to be almost impossible to "crash." Through the use of the above characteristics, it is difficult to become lost or disoriented at any level of interaction.

Instrument

A self-administered questionnaire, the NCAMD Rating Form (NRF), consisting of a mixture of 27 open-ended and closed-ended items, was developed for use in this study. The development of the NRF was based upon the objectives of the study, available literature, and expert opinion. The NRF was designed to gather information that would answer questions in the conceptual areas of system utility and software and hardware performance. Some of the items in these conceptual areas were created to address the problems associated with the implementation of NCAMD programs that de Dombal (1990a) has outlined. Other items were designed to gauge the extent to which the goals (see above, Roth et al., 1989) of developing a user-friendly interface for NCAMD were achieved.

Subjects

Twenty-seven IDCs and 3 GMOs were solicited as voluntary subjects. Nineteen IDCs and 1 GMO, serving aboard 5 surface ships and 8 submarines, returned surveys. Four of the subjects' data were deleted from analyses because of missing data. The IDCs ranged in paygrade from E-5 (Second Class Petty Officer) to E-8 (Senior Chief Petty Officer), had performed on independent duty for more than 1 year, their length of service ranged from 8 to 22 years, and they had completed basic corpsman "A" school and the more specialized Independent Duty Corpsman's School. The GMO was an O-3 (Lieutenant)and had served in the Navy for approximately 2 years. Additionally, 2 GMOs (O-3s) and 2 IDCs (one E-7 and one E-8) participated in focused interviews.

All subjects had some experience with a computer. Four were their department's computer software specialist, 11 had done maintenance on the department's system (6 doing backups regularly), 12 had used software packages other than SAMS and NCAMD (6 respondents had used spreadsheets or word-processing software), and 2 had not used SAMS or other patient management systems.

Procedure

The IDCs and GMOs were briefed on the objectives and requirements of the study and given a copy of the study protocol, medical encounter forms, evacuation forms, and the CRF. IDCs and GMOs attached to vessels

in which the system could not be installed by NHRC personnel were given intensive training and familiarization in the installation and use of the NCAMD system. IDCs and GMOs attached to vessels wherein NHRC personnel could install NCAMD were given abbreviated training in its use.

Results

Descriptive results of the NRF will be given first, followed by the results of the focused interviews. The GMO's responses were similar to those of the majority of IDCs. Therefore, the GMO's responses are grouped with those of the IDCs, and both are referred to as respondents or clinicians. The results of the NCAMD evaluation will be separated into the three conceptual categories listed in the Method section of system utility, software performance, and hardware performance.

Modal and mean responses will be given where appropriate. Means were computed by coding the responses from lowest (1 = "poor," "rarely," "not accurate at all," and "not useful at all") to highest (4 = "excellent," "always," "very accurate," and "very useful") of a four-category, forced-choice scale.

System Utility

Five of the items used to assess the utility of the NCAMD system are summarized in Table 1. For these items respondents were asked to rate on a four-category, forced-choice scale: (1) how often the system was used from "daily" to "less than once a month," (2) the usefulness of the system's training mode from "poor" to "excellent," (3) the difficulty of generating a diagnosis with NCAMD from "very easy" to "very difficult," (4) the accuracy of the system from "very accurate" to "very inaccurate," (5) the usefulness of the reports generated by NCAMD from "very useful" to "not useful at all." The grand mean rating for these items assessing the utility of the NCAMD is 2.6 of a possible 4.0.

Table 1

Mean and Modal Responses Related to the Utility of NCAMD System (n = 16)

Item	Response	
	Mean	Mode, n
Frequency of Use	"less than once a month" (1.2)	"less than once a month," 13
Utility of Training Mode	"good" (2.8)	"fair," 7
Generating a Diagnosis	"somewhat easy" (2.6)	"somewhat easy," 8
Accuracy of Information	"somewhat accurate" (3.2)	"somewhat accurate," 9
Utility of Reports	"somewhat useful" (3.0)	"somewhat useful," 7

Clinicians were asked to estimate the most-used to least-used NCAMD functions. Nine said they mostly used it as a "training tool," and 4 said they used it as a "treatment/diagnostic reference." Nine clinicians said that "Patient registration" was the least-used function.

The effect the use of NCAMD had on health care was assessed along a forced-choice, three-category scale for five factors and the results are summarized in Table 2. One clinician did not respond to factors 2 and 3. The first factor was the effect the system had on the amount of time for a patient examination. The second factor was the effect the system had on the thoroughness of the examination. Factor 3 dealt with the effect the system documentation had on health care. The fourth factor concerned the ability of the clinician to reach a diagnosis. Factor 5 concerned the effect of treatment information on health care.

Table 2

The Effect of NCAMD on Health Care

	Factor	Rating					
		Positive, n		Neutral, n	Negative, n		
1.	Time required for examination	Less,	0	0	Lengthened,	16	
2.	Thoroughness of examination	More,	8	6	less,	1	
3.	Effect of documentation on health care	Improved,	9	5	worse,	1	
4.	Ability to make diagnosis	Improved,	9	6	less,	1	
5.	Affect of treatment information on health care	Improved,	11	5	worse,	0	
	Total		37(47%)	22(28%)		19(24%)	

The clinicians were asked to list other diagnostic modules they would like added to NCAMD. Nine said they would like to have a dental module, 10 a dermatological module, 5 a musculoskeletal module, seven a gynecological module, 5 a psychiatric module, and 9 a trauma module. Some respondents indicated they would like to have more than one of the listed modules.

Software Performance

Eight items were used to collect information concerning the performance of the software in the NCAMD system, and the responses are summarized in Table 3. The clinicians were asked to rate on a four-category, forced-choice scale: (1) the ease of learning the NCAMD system from "very easy" to "very difficult," (2) the Help feature of the system from "poor" to "excellent," (3) how often the system prompted for correct information from "always" to "rarely," (4) how often sign and symptoms

were displayed in a meaningful order from "always" to "rarely," (5) the ease of generating a diagnosis from "excellent" to "poor," (6) the accuracy of the system diagnosis from "very accurate" to "very inaccurate," (7) the accuracy of treatment information from "very accurate" to "very inaccurate," and (8) how well the system interfaces with SAMS from "excellent" to "poor." Overall, the grand mean rating for these items assessing software performance was 2.9 of a possible 4.0.

Table 3

Mean and Modal Responses Related to NCAMD Software Performance (n = 16)

Item	Response	
	Mean	Mode, n
Ease of Learning	"somewhat easy" (3.2)	"somewhat easy," 9
Help Feature	"good" (2.7)	"Fair," 6; "good," 6
Accuracy of Prompt	"usually" (2.8)	"usually," 9
Meaningful Signs and Symptoms	"usually" (2.9)	"usually," 10
Ease of Diagnosis	"good" (2.6)	"good," 8
Accuracy of Diagnosis	"somewhat accurate" (3.1)	"somewhat accurate," 8
Accuracy of Treatment Information	"somewhat accurate" (3.2)	"somewhat accurate," 13
System Interface	"good" (2.5)	"good," 6

Hardware Performance

Information related to hardware performance was collected with 6 items and focused interviews. One item asked respondents to indicate their opinion of their computer's response time on a four-category, forced-choice scale from "poor" to "excellent." The mean (M = 2.2) and modal response was "fair." The other 5 items consisted of open-ended questions. Summaries will not be given for these items because many clinicians did not respond and because the purpose of the items was to solicit qualitative criticisms of the system. Overall, the questions elicited a balance of both positive and negative remarks concerning the system and also comments regarding suggested improvements to NCAMD. Regardless of future hardware additions to the NCAMD system, respondents said they would like to have a modem or satellite link with a Battle-Group or shore-based physician and computers with at least 386 CPUs. In the area of future peripheral material, additions to the NCAMD system respondents said they would like chest pain data sheets and more reference materials. Respondents thought the diagnosis of "nonspecific abdominal pain" was confusing and should therefore be deleted from the system. A few statements were received indicating the prompt to enter electrocardiogram (ECG) and electrolyte data should be deleted because most units did not have the equipment to gather these data.

Positive comments included: the system is "...useful in organizing thoughts prior to speaking to Battle Group Surgeon," "easy to use and user-friendly," "...liked Help screens," "liked using it as a training tool," "good trauma tool," and "fun for learning." Negative comments included: using the system is "...time-consuming," the system is "...a waste of time," "treating patient while using the system is constraining," and the system was "...too slow..." and "...needs to be faster...," and "it prevents the corpsman, or allows the corpsman to rely on a program rather than using the art of medicine to diagnose and treat a patient."

Focused Interviews

Focused interviews (Merton, Fiske, & Kendall, 1956) were conducted with two GMOs (O-3s) and two IDCs (one E-7 and one E-8). The results of the interviews were similar to those of the questionnaire survey; therefore, only the results that differed from those of the questionnaire will be presented. The comments of the interviewees will be summarized into two categories: suggested changes to NCAMD and general remarks. Because the comments of the GMOs did not substantially differ from those of the IDCs, they will be presented as a group.

The interviewees suggested that printouts of disease and treatment references and the ability to write encounters to the sick-call log would increase the administrative value of the NCAMD system. A suggestion was also received to add CD-ROM capability to the system to allow it to store and retrieve illustrative material.

Interviewees stated that the addition of the following modules would significantly increase usage of the system: genitourinary diseases, infectious diseases of the head and neck, and psychiatry.

General comments received from the GMOs and IDCs included: "One or two cases a month are serious enough to use CAMD;" "A printout of diagnostic results would improve the credibility of the IDC to the CO;" "CAMD familiarization should be part of IDC school curriculum, stress limitation of system;" "Reduce the amount of stimuli on the screen, too distracting in stressful situations;" and "Reference source may be better than a diagnostic aid."

Discussion

For the purpose of discussion the results of the evaluation of NCAMD system will be separated into the three conceptual categories that are listed in the Method and Results sections. The three categories are system utility, software performance, and hardware performance. The system utility category will include responses to items and interviewee comments related to the general usefulness of the system and the implications of using the system. Results related to software performance include responses to items and interviewee statements related to suggested additions and deletions. The category of hardware performance was included because available hardware intrinsically affects the use of NCAMD. Consequently, NCAMD software cannot be evaluated apart from hardware. Therefore, item responses and interviewee remarks will be integrated to provide a summary of hardware performance.

System Utility

Although most of the clinicians stated the utility of the system was good to excellent, the results suggest NCAMD is being used less than monthly, primarily for training, and usually as a diagnostic reference tool after an initial diagnosis has been completed.

The frequency of NCAMD use appeared to be directly related to the incidence of abdominal and chest pain patients, the processing capability of available computer hardware, and the ability of the clinicians to integrate NCAMD into examination procedure. Respondents stated few chest and abdominal pain cases are seen each month, and the available computer hardware is tediously slow. They felt using NCAMD while examining a patient was difficult due to the processing speed of available computers and the need to interact with the patient and the computer simultaneously. Therefore, when NCAMD was used it lengthened the time required to examine a patient. Dallos and Cunningham (1990) found the use of NCAMD and structured forms with abdominal pain patients added about 4 minutes to the work load for each patient. However, other studies, including Dallos and Cunningham (1990), Patterson-Brown et al., (1989), and the present study found that using NCAMD in conjunction with patient examinations make such examinations more thorough. Finally, Patterson-Brown and Vipond (1990) found the use of structured data collection forms greatly improves the diagnostic accuracy of clinicians.

Overall, little use was made of NCAMD as a reference for patient data. For NCAMD to be used routinely as a patient reference, all patient encounters would have to be entered and the present data show this was not done.

There was agreement that generating and reaching a diagnosis on NCAMD was relatively easy, and the information NCAMD provided was accurate. Diagnostic information is related to treatment data within NCAMD, and respondents stated the system provides better treatment information than they normally have available. Most respondents felt the documentation NCAMD provided was useful and generally improved the quality of health-care services. This supports the results of an analysis of the legal and ethical clinical use of computers done by Miller, Schaffner, and Meisel (1985) who found computers should only be used if they improve the quality of medical care.

The present results suggest the utility and use of NCAMD would be increased if more reference materials were added to NCAMD. Suggested areas were dental, dermatological, musculoskeletal, gynecological, psychiatric, trauma, infectious diseases of the head and neck, and genitourinary. Nice (1984) found the leading cause for at-sea communications were diagnoses associated with trauma, dental, abdominal and chest pain, infectious diseases, mental disorders, genitourinary, and nervous system and sense organs, respectively. IDCs and GMOs initiated communications to elicit a consultation concerning the suspected diagnoses. Taken together, the present results and those of Nice (1984) suggest NCAMD consultations in the diagnostic areas of trauma, dental, infectious disease, mental disorders, and genitourinary would be of particular value to at-sea clinicians.

In summary, NCAMD was used more often for training than for patient evaluation or treatment. The two most prominent reasons for the lack of NCAMD use in direct patient care are the slowness of available computer CPUs and the unavailability of pertinent diagnostic and treatment information. NCAMD utility and use would be increased by providing clinicians with computers with faster CPUs and easy accessibility to more diagnostic and treatment reference materials. However, the present value of NCAMD as a training tool for diseases of the chest and abdomen should not be underestimated. Many studies have shown the use of a CAMD system improves clinician performance. Clinician performance appears to improve due to the use of a consistent and structured method of data collection via a CAMD system that provides feedback and a focus on education (de Dombal, 1990a, 1990b, 1991). Therefore, the value of the NCAMD system as a diagnostic tool is often of indirect value. Through the use of NCAMD as a training tool, the clinician's diagnostic skills are improved, and he or she is then better able to diagnose trauma and disease.

Software Performance

All respondents stated the NCAMD system was easy to learn. The ease of learning was probably related to the user-friendliness of the system, which was rated as "good" by the majority of respondents. Among the prominent features added to NCAMD to aid in learning the system were the Help windows, which most of the respondents stated were "good" to "excellent." De Dombal (1990a) stated there are three major reasons why clinicians do not use NCAMD systems more often. The first reason is they take time to use, and the second reason is they require computer skills. The third reason is related to the first two, and it is the inability to type proficiently. He further stated the one area of clinical computing that requires urgent action is the development of user-friendly interfaces. The NCAMD system has responded to some of these findings since it requires minimal time to operate and, although data entry requires the use of the keyboard, most functions can be accomplished via a mouse. Also, as proficiency is achieved on the system and baseline data have been entered for personnel, the system should save time and effort.

The perceived accuracy of NCAMD was judged to be reliable and the majority of the respondents indicated it usually prompted for correct information. Generally, respondents stated the diagnoses NCAMD generated were correct and treatment information was rated as "very accurate." Most respondents felt signs and symptoms were displayed in a meaningful order, and this factor probably contributed to respondents finding it was easy to generate a diagnosis.

To ultimately use NCAMD as an administrative aid it has been interfaced with SAMS. Most respondents rated this interface as "good" and some though it was "excellent." Respondents suggested printouts of disease and treatment references and the ability to write encounters to the sick-call log would increase the administrative value of the NCAMD system.

The results of the critique of NCAMD software suggest the software is easy to learn, easy to use, and the information prompted for and generated by NCAMD is reliable and accurate. The diagnosis of "non-specific abdominal pain" was considered confusing and should be deleted

from the NCAMD. The need to enter ECG and electrolyte data should be deleted because small ships and submarines do not have the equipment to gather these data. At present, if ECG and electrolyte data are unknown the user is advised to enter normative data.

Hardware Performance

Although NCAMD users stated that the overall computer response time was slow, the response time for generating a diagnosis was found to be fair to good. The slowness of available computer systems was compounded by the need to manipulate the system and enter data via the keyboard because many sites did not have a mouse. The reporting function was minimally useful, since many of the sites did not have printers.

Regarding potential hardware additions to the NCAMD system, respondents said they would like to have a modem or satellite link with a Battle-Group or shore-based physician and computers with at least 386 CPUs. Such a link to a physician would allow the sea-based clinician to make more timely and informed decisions regarding patient care. Previously, Nice (1984) found at-sea clinical decision-making would be improved by providing clinicians with medical telecommunications technologies that transmit x-ray images and TV images of body parts. In the area of future peripheral material additions to the NCAMD system, respondents said they would like chest pain data sheets and more reference materials. Data sheets allow for a methodical and thorough evaluation of patients while reference materials provide in-depth answers concerning symptomatology and treatment. Wellwood et al. (1992) found when clinicians recorded data on structured information sheets prior to consultation with senior clinicians there was a significant reduction in the number of hospital admissions and fewer operations with negative findings. This would suggest that if at-sea clinicians were provided with structured forms, a variety of NCAMD modules, and a link to senior shore-based clinicians, there may be fewer medical evacuations and fewer unnecessary procedures may be performed at sea. A suggestion was also received to add CD-ROM capability to the system to allow it to store and retrieve illustrative material. In summary, it is evident sea-based clinicians believe their use of NCAMD would improve their performance if it were installed on updated computer hardware. Therefore, when faster CPUs are available NCAMD software may gain greater acceptance.

In response to de Dombal's (1990a) proposal that seven problems must be addressed before CAMD systems are successfully implemented, the present results show: (1) clinicians believe CAMD systems enhance their performance; (2) NCAMD uses a structured method to gather patient data and case histories; (3) NCAMD is user-friendly; (4) no preference for deterministic or probabilistic systems (NCAMD is probabilistic); (5) NCAMD gives the clinician diagnoses in their most probable order (i.e., the most probable first, without giving numerical values), thus enabling the clinician to investigate diagnostic options without being biased by CAMD estimates; (6) NCAMD was of value; however, educating clinicians on the benefits of using CAMD will be a continuing problem that may be resolved by introducing NCAMD to medical, nursing, and IDC students during their earliest training; and (7) IDCs and GMOs are computer-literate and adept at using information technology.

Bankowitz et al. (1989) have stated that evaluations of CAMD systems should focus on effectiveness as well as accuracy. Previous studies of NCAMD have established its objective accuracy, and this report has gauged its perceived accuracy. The goal of future evaluations will be an objective assessment of the impact of the system on quality of care and patient outcome measures. The present results suggest that NCAMD will become widely used when it shows beneficial reductions in length and cost of hospitalization, in the time required to establish an accurate diagnosis, and in the use of health-care resources during the diagnostic process.

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13. ABSTRACT *(Maximum 200 words)*

The objective of this study was to gauge the practical implications of U.S. Navy Independent Duty Corpsmen (IDCs) employing a user-friendly computer-assisted medical diagnostic (CAMD) system to aid in the diagnosis of disease and to perform tasks related to the treatment, evaluation, and management of patients.

The Navy CAMD system was installed aboard U.S. Navy ships and submarines with GMOs or IDCs attached. Both the Group Medical Officers (GMOs) and IDCs were trained in the functioning and use of the NCAMD system, and given the software to use and evaluate during deployment. When they returned from deployment, the GMOs and IDCs were surveyed and interviewed to determine their opinions of the NCAMD system.

The NCAMD software is a cost-efficient and user-friendly package that is easy to learn and is of particular value for training in the diagnosis of chest and abdominal pain. However, the delivery of health care at sea would significantly improve if the computer hardware were upgraded to current industry standards. Also, adding various computer peripheral devices, structured forms, and reference materials to the at-sea clinician's resources could enhance shipboard health care.

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